Design of Modified E Shaped Microstrip Patch Antenna for WLAN/WiMAX, C and S band Applications

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Abstract— In this paper, the bandwidth enhancement of Microstrip patch antenna is done according to modified E – shape from a calculated rectangular patch. The designed antenna is suitable for the use of WLAN/WiMAX applications and lies in range of S and C electromagnetic spectrum band in operating frequency range of 2.60-4.43 GHz and the antenna successfully obtained the percentage bandwidth about 52.062, efficiency (80%) and gain 3.35dB at resonating frequency 4.01 GHz. The designed structure and performance of Microstrip patch antenna is simulated using IE3D (9.0 version) Zealand simulation software. The antenna is fed by 50Ω Microstrip line feed.

Key words: Microstrip Patch antenna, Fractional bandwidth, Ground plane, IE3D simulator, Microstrip line feed

I. INTRODUCTION

In this paper the purpose of new design antenna presents to enhance the bandwidth of Microstrip patch antenna for WLAN/WiMAX application. The bandwidth of microstrip patch antenna is enhanced by modified E-shaped [1] patch. The Microstrip patch antenna have variety of applications such as military, wireless communication, satellite communication, global positioning system (GPS), RF devices, WLAN/WiMAX application[2,3]. The proposed antenna operates in the range of S and C band [4] also useful in WLAN /WiMAX applications. The major drawbacks of microstrip patch antennas are narrow bandwidth and low gain [5].

Many techniques are used to enhance bandwidth and gain of Microstrip patch antennas. By using thick substrate (glass epoxy) having low dielectric constant value and compact slotted patch [6] can enhance the bandwidth and gain of antenna.

The Microstrip patch antenna have some valuable features such as low cost, light weight, high efficiency, simply manufacturing procedure and easy to implement with circuits [3,6,7]. The design structure components of antenna could become small in size and have low processing cost [2].

In this paper transmission line method are used to analysis the rectangular Microstrip patch antenna. The antenna is designed to operate at resonant frequency 4.01 GHz with 50Ω microstrip line feed. The Microstrip Patch Antenna is characterized by thickness (h), dielectric constant (ε_r), and length (L), width (W) of ground plane and patch. The performance of designed antenna is characterized by its radiation pattern, return loss, VSWR and gain. That is obtained on simulation software IE3D.

II. MATHEMATICAL FORMULA TO CALCULATE THE DESIGN DIMENSIONS OF MICROSTRIP PATCH ANTENNA

The mathematical formula is used to calculate the dimensions of ground plane and microstrip patch in the form of length and width.

The formula of calculating the width of Patch antenna

$$W = \left(\frac{c}{2f_r}\right)\left(\frac{\varepsilon_r + 1}{2}\right)^{-.5} \qquad (1)$$

Where: c = 3×10^8 ms^{-1},ε_r=4.4, f_r =2.38GHz
Formula of effective dielectric constant is given as:

$$\varepsilon_{eff} = \left(\frac{\varepsilon_r + 1}{2}\right) + \left(\frac{\varepsilon_r - 1}{2}\right)\left(1 + \frac{12W}{H}\right)^{-.5} \qquad (2)$$

Where: h=1.6mm
Formula of extension in length is given as:

$$\Delta L = .412H\left(\frac{\varepsilon_{eff} + .3}{\varepsilon_{eff} - .258}\right)\left(\frac{\left(\frac{W}{H}\right) + .285}{\left(\frac{W}{H}\right) + .8}\right) \qquad (3)$$

The formula of calculating the length of Patch antenna

$$L = \left(\frac{c}{2f_r\sqrt{\varepsilon_{eff}}}\right) - 2\Delta L \qquad (4)$$

III. ANTENNA DESIGN SPECIFICATION

To calculate the dimensions of the patch, above formulas are used. The parameter required to calculate dimension are resonant frequency (f_r), dielectric constant (ε_r), substrate thickness (h) and loss tangent ($tan\ \delta$) and 50Ω Microstrip line is used as feed into patch. The antenna specifications that are required is given in table1.

S. NO	Antenna Parameter	Data
1.	Resonant frequency (f_r)	4.01GHz
2.	Substrate thickness (h)	1.6mm
3.	Dielectric constant (ε_r)	4.4
4.	Patch length(L)	30 mm
5.	Patch width(W)	38 mm
6	Ground plane length(Lg)	40 mm
7.	Ground plane width(Wg)	47 mm
8.	Loss Tangent ($tan\ \delta$)	0.0013

Table I: Antenna Design Specifications

IV. ANTENNA DESIGN PROCEDURE

By using the above equations and geometrical parameters, the dimensions of the antenna is calculated.

In the way to design the antenna first calculate the dimensions of patch and then make a slot in patch to enhance the bandwidth. Cutting slots in microstrip patch is completely based on hit and trial method. Different dimensional parameters of proposed antenna are given in table II.

A 50Ω Microstrip line feed is used at mid of the bottom of the patch antenna. The position of feed is (Lg/2) on the positive X axis from the origin.

Table II: Antenna Dimensions

S.No	Lengths	Value (in mm)
1.	a	3

2.	b	25
3	c	5
4	d	16
5	e	12
6	f	11
7	g	5
8	h	20
9	i	3
10	j	30
11	k	28
12	l	13
13	m	10
14	n	4
15	o	10
16	p	13

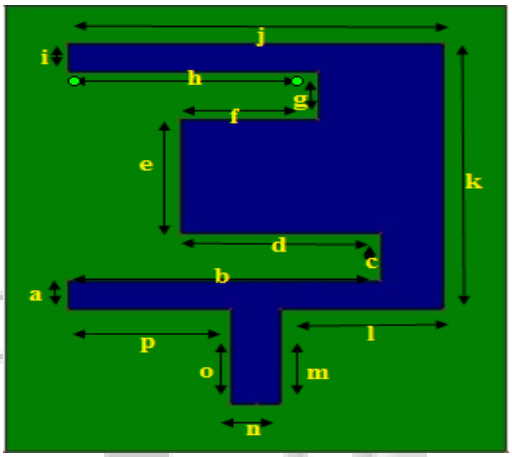

Fig. I: (Geometry of designed antenna variables in mm)

V. SIMULATION RESULT AND DISCUSSION

The Simulation Performance Of Designed Microstrip Patch Antenna Is Analyzed By Using Ie3d Software (Version 9.0) At Design Frequency Of 2.38 Ghz. The Graph Of Return Loss Vs Frequency Is Plotted For The Range Of Frequency 1 GHz To 5 Ghz, Because Within This Range The Curve Crosses- 10 Db Line, Which Can Be Evaluate From Return Loss Curve.

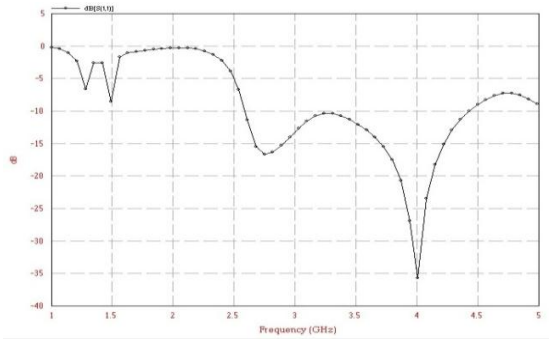

Fig. IV: Return loss vs. Frequency graph

So as in this way we can calculate fractional bandwidth from the given formula shown above.

Now we can see that the enhanced bandwidth 52.062 % of designed antenna is obtained and curve shows resonance at 4.01GHz.

In figure (II), the graph shows Gain Vs Frequency plot .which depicts total field gain of the designed Microstrip patch antenna and maximum gain of antenna is 3.35 dB at 4.01 GHz.

Antenna gain shows how well transmitting antenna converts the input power into radio waves.

Gain is calculated at resonance frequency of the antenna, so as to calculate, we check the value of gain at resonance frequency i.e 3.35 dB.

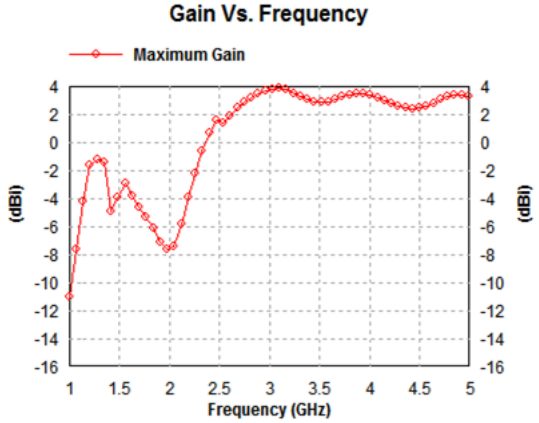

Fig. II: Gain vs. Frequency plot

In figure (III), the graph plotted between efficiency Vs frequency represents radiating efficiency and antenna efficiency. The obtain percentage antenna efficiency is 80 at 4.01GHz.

Antenna efficiency means the ration of total power radiated by antenna to net power accepted by the taken antenna.

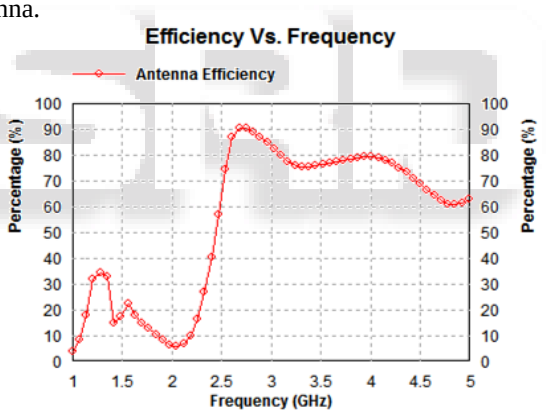

Fig. III: Efficiency vs. Frequency plot

In figure (V) the graph of 2D radiation pattern of antenna is plotted. The radiation pattern represents radiation of all power in two direction therefore it shows that the designed antenna bidirectional.

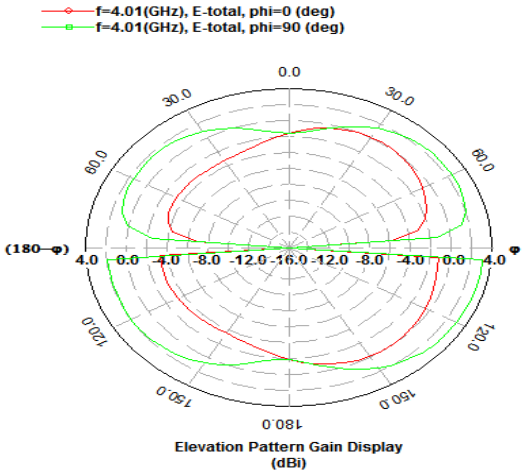

Fig. V: 2D Radiation pattern of antenna

In figure (VI), the graph of total field Directivity Vs Frequency is plotted.

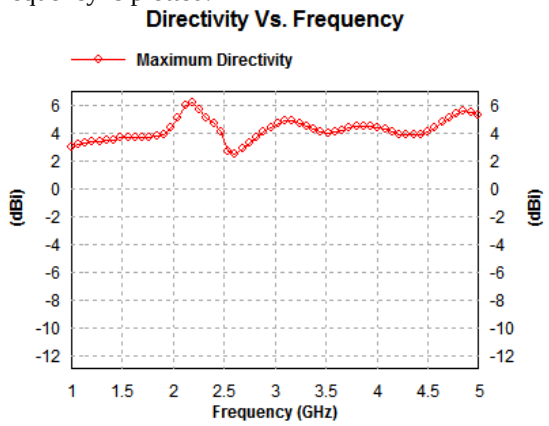

Fig. VI: Directivity vs. Frequency plot

VI. Conclusion

The return loss and radiation patterns of the E-shaped slotted antenna presented in this paper clearly showed that the antenna is wide band antenna and worked in multiple frequency bands with bidirectional lobe.

Microstrip patch antenna fed with 50Ω Micristrip line feed has been designed. The enhanced percentage bandwidth of design antenna is approximately 52.062% and gain (3.35dB), efficiency (80%), is obtained at resonant frequency of 4.01GHz. The simulated result of design antenna shows good performance and hence can be used in WLAN/WiMAX application.

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